Token Threading on the MSP430

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Forth2020 Virtual Meeting
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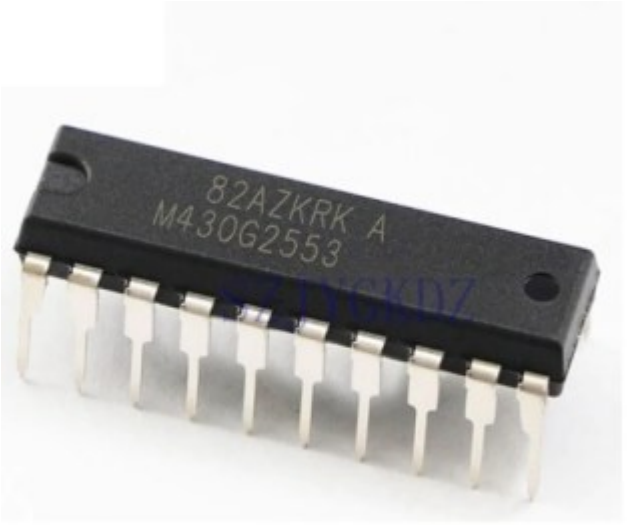
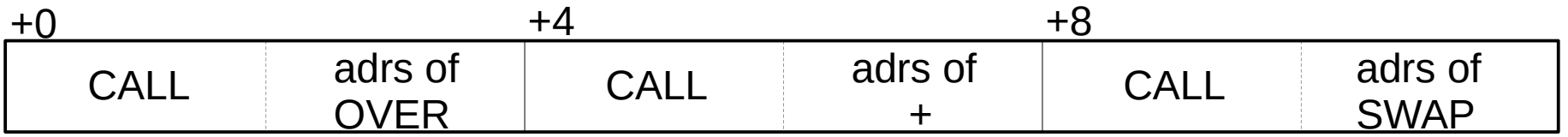
The Target

- MSP430G2553
- 16-bit CPU
- 512 bytes RAM
- 16 KB Flash ROM
  - 8 KB CamelForth kernel
  - 8 KB user application

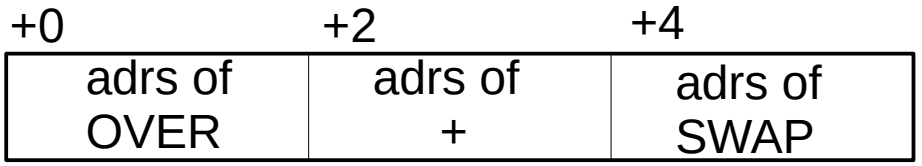


OVER + SWAP

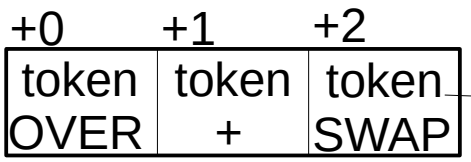
- Subroutine Thread

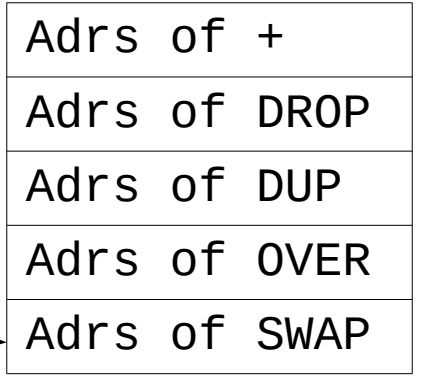


- Address Thread



- Token Thread





Extensible vs. Hybrid

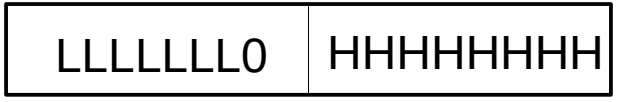
- All words have tokens
  - Extensible token table
  - Large or “creative” encoding
- Selected subset has tokens
  - Fixed size token table
  - Fixed size token (e.g. 8 bits)
  - Mechanism to reference other words

Hybrid Token/Non-Token Model

- CALL token

- Special encoding
  - Token

  - Address



ITC vs TTC NEXT

- ITC

```
.macro NEXT
        MOV @IP+,W
        MOV @W+,PC
.endm
```

TTC

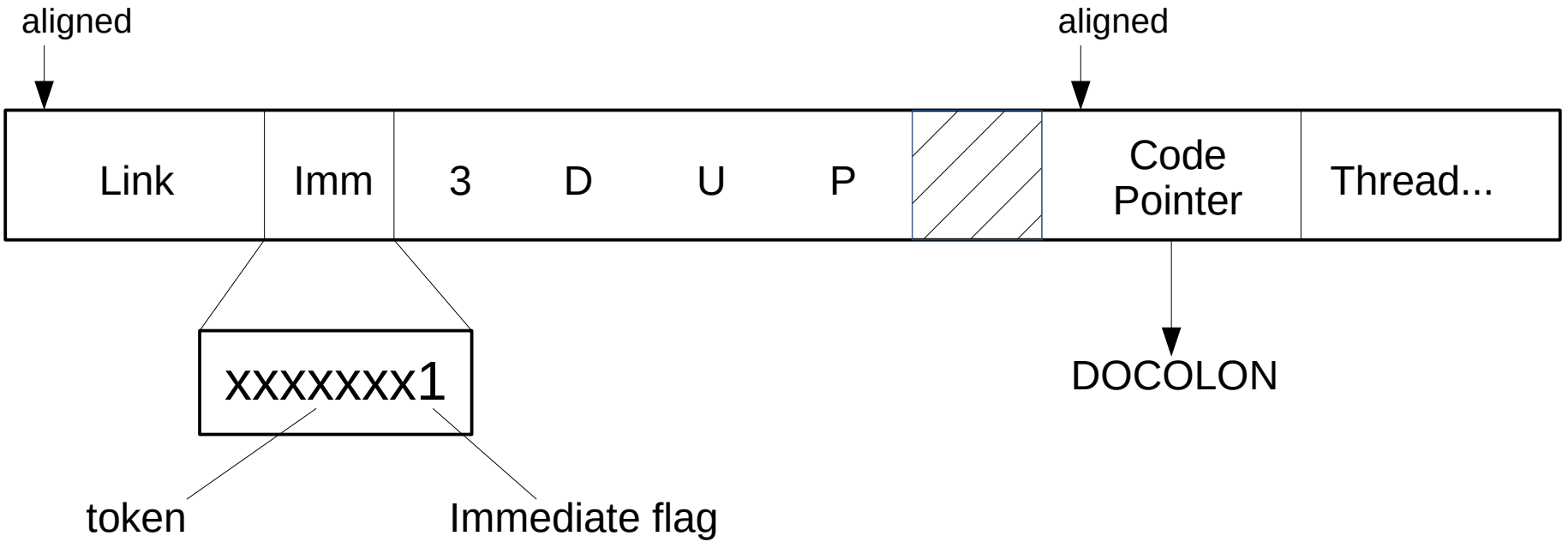
```
_NEXT_: MOV.B @IP+,W
        BIT.B #1,W
        JNZ _ISTOKEN_
; not a token - fetch address
        MOV.B @IP+,X
        SWPB X
        BIS X,W
        MOV @W+,PC

_ISTOKEN_:   ; W contains 00tt
        MOV TOKENTABLE-1(W),W
        MOV @W+,PC
```

The Token Table

	x1	x3	x5	x7	x9	xB	xD	xF
0x	0	1	2	-1	1CHARS	CELL	lit	clit
1x	EXIT	DUP	?DUP	DROP	SWAP	OVER	ROT	NIP
2x	TUCK	>R	R>	R@	SP@	SP!	RP@	RP!
3x	@	!	C@	C!	I@	I!	IC@	IC!
4x	+	+!	M+	-	AND	OR	XOR	INVERT
5x	NEGATE	><	1+	1-	2*	2/	LSHIFT	RSHIFT
6x	0=	0<	=	<>	<	>	U<	U>
7x	branch	?branch	(do)	(loop)	(+loop)	UNLOOP	I	J
8x	EXECUTE	UM*	UM/MOD	EMIT	KEY	KEY?	CELL+	CHAR+
9x	FILL	CMOVE	CMOVE>	D->I	SKIP	SCAN	S=	N=
Ax	*	/	MOD	*/	/MOD	*/MOD	MAX	MIN
Bx	UMAX	UMIN	2DUP	2DROP	2@	2!	2SWAP	2OVER
Cx	TYPE	SPACE	CR	<#	#	#S	HOLD	#>
Dx	LATEST	IDP	IHERE	IALLOT	HERE	ALLOT	,XT	I,
Ex	IC,	CCLRB	CSETB	CTSTB	CLRB	SETB	TSTB	CELLS
Fx	sbranch	s?branch						NOOP

Forth Word Layout



What should the ‘xt’ be?

- ‘xt’ is
  - if odd, an 8-bit token
  - if even, a 16-bit CFA
- Produces xt: FIND ‘ [‘]
- Consumes xt: EXECUTE COMPILE, >BODY

```
HEX ‘ DUP U.  13 ok
```

Other Optimizations

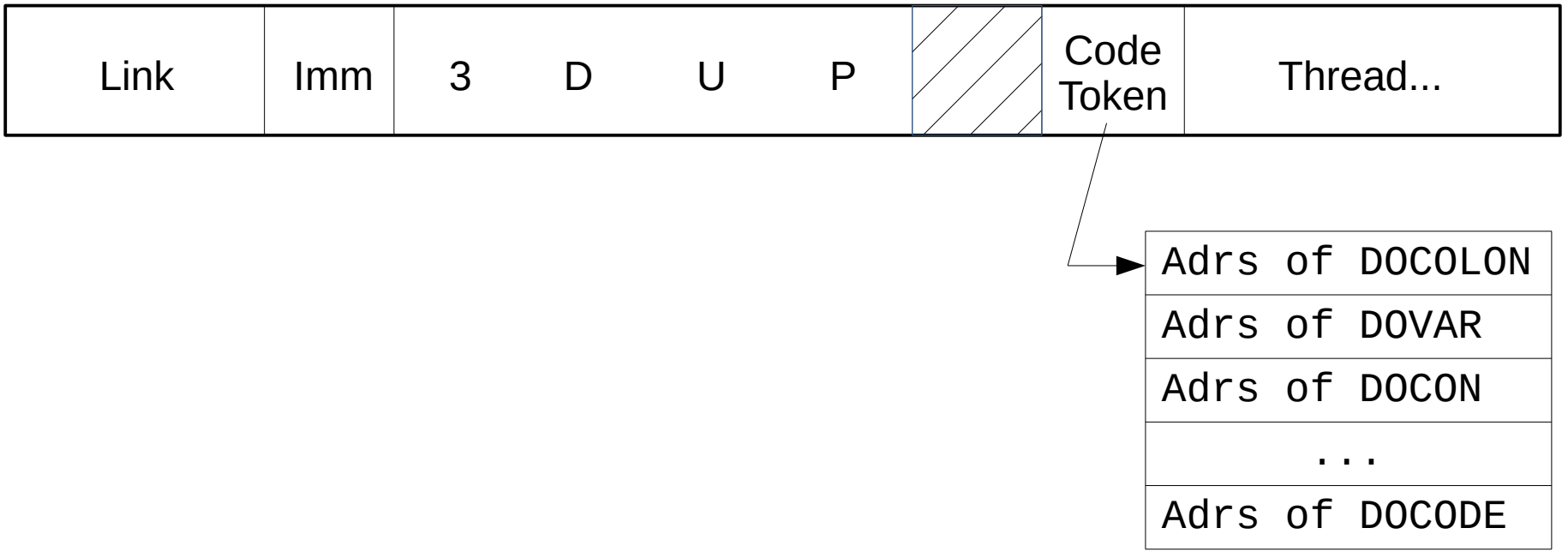
- Short literals (-128..+127)
- Short branch offsets
  - branch and ?branch only

Results

- ITC MSP430 CamelForth 0.5
  - 7276 bytes (< 7.5 KiB)
  - DO I DROP LOOP takes 3.88 usec
- TTC MSP430 CamelForth 0.1
  - 6580 bytes (< 6.5 KiB)
  - DO I DROP LOOP takes 7.50 usec

Future Work

- Token Action, Token Thread



Questions?

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